

PASSENGER PROTECTION DEVICE

Background of the Invention

The present invention relates to a passenger protection device, in particular for a motor vehicle, having at least one airbag, at least one gas generator for filling the airbag, an 5 airbag control device for activating the airbag, means for acquiring the speed of deployment of the airbag, and means for regulating the filling quantity of the airbag, taking into account its deployment speed.

Airbags in a motor vehicle are generally allocated to a 10 particular seat, or to the passenger occupying that seat. The braking action of an activated airbag is standardly designed such that the risk of injury for the corresponding passenger in the given accident situation is minimized as long as the 15 passenger is sitting in an upright position at the moment at which the airbag is triggered, and is held by the available safety belts, and is leaning against the back rest of the seat. Under these preconditions, the passenger will at first be situated at a certain distance from the fully inflated 20 airbag before falling into it. However, it may also occur that at the moment of the accident the passenger is in a different position, for example leaning forward. Such "Out-of-Position", or OoP, situations can result in very serious injuries to the 25 passenger if he or she comes into contact with the deploying airbag and the filling of the airbag takes place in an uncontrolled manner. For this reason, various designs have already been developed for acquiring the deployment speed of an airbag in order to reduce the filling quantity if an "obstacle" is situated in the deployment path of the airbag.

In international patent application WO 03/039918 A1, a passenger protection device is described that includes an airbag having a filling device for inflating the airbag. Here the deployment speed of the airbag is acquired in contactless fashion. For this purpose, a transceiver device for electromagnetic waves is provided, and what is known as an interrogation unit is provided that is situated on the airbag cover. While the airbag is deploying, the transceiver device sends electromagnetic waves to the interrogation unit, which moves with the airbag cover. The response signal sent by the interrogation unit to the transceiver device is then evaluated by an evaluation unit connected to the transceiver device.

The measures described in international patent application WO 03/039918 A1 make it possible to control the filling quantity of an airbag dependent on its deployment speed. However, in practice a correspondingly controlled filling of an airbag proves to be problematic, because the total duration of the inflation must last only about 30 ms.

#### Advantages of the Present Invention

The present invention proposes a passenger protection device of the type described above having means that are easy to realize constructively for a controlled filling of the airbag dependent on its deployment speed.

For this purpose, the passenger protection device according to the present invention is equipped with at least one discharge valve situated between the gas generator and the airbag, the actuating means for sealing the flow-off valve being capable of being controlled.

According to the present invention, it has been recognized that via such a controllable flow-off valve, acting in the outward direction, it is easy to divert a defined quantity of

the pressure gas if an obstacle is detected in the deployment path of the airbag, or if the presence of such an obstacle is indicated by the deployment speed of the airbag. The quantity of filling for the airbag can in this way easily be controlled  
5 in a manner that takes into account the deployment speed, or the size and position of an obstacle in the deployment path.

Most passenger protection devices are equipped with a central airbag control device to which all possible information is provided concerning the state of the vehicle, the occupation  
10 of the seats, the traffic situation, etc., in order to recognize dangerous situations as reliably as possible and then to activate suitable restraint means. In this case, it often proves advantageous if the means for acquiring the deployment speed of the airbag and the actuation means for  
15 sealing the flow-off valve are also connected to the airbag control device. On the one hand, the airbag control device has means suitable for evaluating measurement data that can also be used to determine and interpret the deployment speed, while on the other hand the information available to the airbag  
20 control device, for example information about seat occupancy, can also be taken into account in the interpretation of the determined deployment speed and its regulation. Moreover, the signal propagation times between the acquisition of measurement data during the airbag deployment and the  
25 controlling of the flow-off valve can be minimized with the aid of a central airbag control device.

On the one hand, the seal of the flow-off valve must be designed such that when the flow-off valve is closed a sufficiently large throttle effect is achieved for the gas  
30 flowing out of the activated gas generator, so that the airbag is completely inflated with maximum speed. On the other hand, the flow-off opening must be dimensioned such that when the valve is open a significant quantity of gas can flow outward,

so that the airbag is not completely inflated. Moreover, in  
order to be able to regulate the deployment speed or filling  
quantity of the airbag at all, it must be possible to realize  
a very rapid valve stroke. In this connection, it proves  
5 advantageous if the actuating means for sealing the flow-off  
valve include a piezoactuator connected to a mechanical or  
hydraulic lever device. In another advantageous variant of the  
passenger protection device according to the present  
invention, the seal of the flow-off valve is actuated with the  
10 aid of an electromagnet.

In principle, the passenger protection device according to the  
present invention can be realized with any type of gas  
generator, the physical and chemical properties, in particular  
the flow-off speed, of the gas or gas mixture used being taken  
15 into account in the design of the flow inlet valve. In a  
variant that is particularly easy to manipulate and also  
economical, the passenger protection device according to the  
present invention is equipped with a cold gas generator that  
is filled with a noble gas mixture under pressure and is  
20 equipped with a pyrotechnic charge for destroying the burst  
disk.

The use of a noble gas mixture for inflating the airbag also  
proves advantageous with regard to the acquisition of the  
deployment speed. Because noble gas mixtures are very clean,  
25 light can propagate in such a medium in unhindered fashion.  
Optical measurement methods for determining the deployment  
speed therefore provide very reliable results. An advantageous  
variant of the passenger protection device according to the  
present invention has for this purpose a transceiver device  
30 with which optical signals, for example in the form of pulsed  
infrared light, are sent into the deploying airbag. Moreover,  
the inside of the airbag is provided at least in some parts  
with a light-reflecting coating, so that the optical signals

are reflected and thus sent back to the transceiver device. The deployment speed of the airbag can then be determined easily through propagation time measurement, using the Doppler effect or a triangulation method.

## 5 Drawings

As discussed above, there are various possibilities for constructing and developing the teaching of the present invention in an advantageous manner. For this purpose, reference is made on the one hand to the patent claims subordinate to patent claim 1, and on the other hand to the following description of an exemplary embodiment of the present invention based on the drawings.

- Figure 1 shows a block diagram of a passenger protection device according to the present invention,
- 15 Figure 2 shows a schematic representation of the passenger protection device shown in Figure 1,
- Figure 3 shows a top view of the seal of the flow-off valve shown in Figure 2, and
- 20 Figure 4 shows a piezoactuator as an actuating device for the seal, shown in Figure 3, of a flow-off valve.

## Description of the Exemplary Embodiment

The overall system shown in Figure 1 of a passenger protection device for a motor vehicle includes an airbag 1 which is filled as the need arises with the aid of a gas generator 2. Gas generator 2 is connected to a central airbag control device 3 to which all available data are supplied concerning the state of the vehicle, the driving and traffic situation, seat occupancy, etc., as indicated by arrow 4. By evaluating

this information, airbag control device 3 can recognize dangerous situations ahead of time, and for example can classify the severity of the crash and the type of the crash in order to initiate suitable preventive measures. Thus, in 5 some dangerous situations airbag control device 3 can activate gas generator 2 via a signal line 5 in order to trigger airbag 1.

In order to ensure the functional capability of gas generator 2, in the exemplary embodiment shown here the gas pressure in 10 gas generator 2 is continuously monitored. For this purpose, the corresponding data are transmitted to airbag control device 3 via a signal line 11. In addition, airbag control device 3 is connected to the microphone 12 of a hands-free communication device installed in the motor vehicle, which in 15 the case of an accident is activated together with a crash recorder. In this way, the sequence of events in the accident, as well as the triggering of the restraint means, can be documented in the form of acoustic signals.

Gas generator 2 is connected to airbag 1 via a connecting 20 module 6 and a measurement module 7 connected before airbag 1. Measurement module 7 is used to acquire the deployment speed of airbag 1, and is explained in more detail in connection with Figure 2. The evaluation of the measurement values can take place in measurement module 7 and/or in airbag control 25 device 3, which is connected to measurement module 7 via a bidirectional line 8.

The filling quantity of airbag 1 can be controlled with the aid of connecting module 6, which has for this purpose at least one flow-off valve 10, shown in Figure 2. The seal of 30 the flow-off valve can be controlled by airbag control device 3 via a signal line 9. In the exemplary embodiment shown here, airbag control device 3 takes over the controlling of the

filling quantity, taking into account the deployment speed of airbag 1, which has been determined with the aid of measurement module 7. The actuating means for the seal of flow-off valve 10 are explained in more detail in connection  
5 with Figures 3 and 4.

The situation of flow-off valve 10 between gas generator 2 and airbag 1 is essential for the functioning of the passenger protection device according to the present invention. Figure 2 shows an advantageous specific realization of such a  
10 situation. Here, flow-off valve 10 is formed in the housing wall of a housing part 20 that acts as a connecting module 6. Airbag 1 is connected to housing part 20 via an opening, situated opposite flow-off valve 10, in the housing wall. Figure 2 shows airbag 1 in the compressed state.

15 As gas generator 2, a pressure vessel 21 is used that is filled with a suitable noble gas mixture. The noble gas mixture can for example be a mixture of 94% argon and 6% helium under a pressure of approximately 500 bar, or can also be an argon-nitrogen mixture. Gas generator 2 is likewise  
20 connected to housing part 20, so that the seal of pressure vessel 21, formed by a burst disk 22, is situated over another opening in the housing wall. Burst disk 22 can be destroyed with the aid of a correspondingly dimensioned pyrotechnic charge 23 situated on the housing wall, opposite gas generator  
25 2. The gas under pressure then flows out of pressure vessel 21 through housing part 20, on the one hand into connected airbag 1, and can on the other hand flow outward via flow-off valve 10, if this valve is open.

Here the measurement of the deployment speed of airbag 1, or,  
30 more precisely, the speed of movement of the upper side of the airbag facing the passenger, takes place optically. For this purpose, in the interior of housing part 20 there is situated

a transceiver device 24 with which optical signals, for example pulsed infrared light, are sent into the deploying airbag 1. These signals are reflected on the inside of airbag 1, which has for this purpose a light-reflecting coating 25 on 5 at least some parts. Because the noble gas mixture flowing into airbag 1 is very clean, optical signals can propagate here in unhindered fashion. From the change of the "time of flight" of the reflected pulsed infrared light, the speed of movement of the airbag upper side facing the passenger can be 10 calculated. Of course, the deployment speed can also be determined using other optical measurement methods, in which for example the Doppler effect or a triangulation method is used.

If the deployment speed decreases before the airbag has been 15 completely inflated, this indicates the presence of an obstacle in the deployment path of the airbag. As a rule, this indicates an out-of-position situation. In order to prevent the passenger from being injured by the deploying airbag, a part of the filling gas flowing out of gas generator 2 can now 20 be diverted outward with the aid of flow-off valve 10, as indicated by arrows 26. Nonetheless, airbag 1 should cushion an impact of the passenger as well as possible. Therefore, the quantity of the filling gas diverted outward is regulated in such a way that the overall risk of injury to the passenger is 25 minimized as much as possible.

As already mentioned, Figure 3 shows a top view of the seal of flow-off valve 10 shown in Figure 2, corresponding to a top view of the sectional plane designated AA. Here, flow-off valve 10 is realized in the form of a sealing panel in the 30 wall of connecting part 20, having an essentially quadratic opening 13, and having a sealing part 14 that is dimensioned corresponding to opening 13 and is held in opening 13 with the aid of actuating means 15, or, given a corresponding

controlling of actuating means 15, can be lifted more or less away from opening 13.

In the exemplary embodiment described here, opening 13 has a surface of approximately  $0.5 \text{ cm} \times 0.5 \text{ cm} = 2.5 \text{ cm}^2$ . Because the 5 gas generator contains an excess quantity of filling gas, the seal of flow-off valve 10 must not be tight. As a rule, the throttle effect for the gas pressing outward is still sufficient if a narrow slit, approximately 0.1 mm in width, remains when the valve is closed. Given a valve stroke of 10 approximately 1 mm, a free surface results of  $0.25 \text{ cm}^2$ , with a slit width of 0.5 mm, if the wall thickness of connecting part 20 is 0.5 mm at the valve point. For a gas pressure of 200 bar, a force of 0.5 kN, which must counteract actuating means 15, acts on the sealing panel. If an airbag inflation time of 15 30 ms is assumed, a complete valve stroke should not last longer than 0.5 ms in order to be able to quickly regulate the movement speed of the front side of the airbag. This requirement could be met for example by a correspondingly dimensioned fast electromagnet that directly actuates sealing 20 part 14.

However, actuating means 15 can also include a piezoactuator 17 designed for the deployment of a high degree of force. Piezoactuator 17, shown in Figure 4, is realized in the form of a 50 mm high piezo stack that undergoes an expansion of 25 0.125 mm at a drive voltage of 300V. In order to achieve with this a stroke of 1 mm of sealing part 14, a stroke multiplication is required, which can be realized for example with the aid of a mechanical lever 18 having eightfold multiplication, as shown in Fig. 4. Here, lever 18 presses on 30 the piezo stack with a force of 0.4 tons, which this stack can withstand in the compression direction, but not in the tensile direction or shear direction. Therefore, piezoactuator 17 must

here be operated in such a way that the flow-off valve is opened when the piezo stack expands.